Physics

ENERGY DEPENDENCE OF PROTON ELASTIC SCATTERING POTENTIALS[1], Jennifer Brace, Srikanth Balaji, Aruna Nadasen*, Kanthode G. Rao, University of Michigan-Dearborn. (Nadasen@umd.umich.edu).

Studies of proton elastic scattering from nuclei have been carried to determine the nuclear forces the proton experiences as it gets close to the nucleus. The elastic scattering data are analyzed by solving the Schrodinger equation. In these analyses, the nucleus is regarded as a potential and the proton is taken to be a wave scattered by the potential. This approach is referred to as the optical model, because of its analogy with optics.

Since the potential represents the nucleus, it is given a spherically symmetric shape with a skin. The skin is the region where the density goes from its maximum value to zero. Such a shape is called Woods-Saxon and has the form $V(r) = V[1 + \exp(\{r-r_oA^{1/3}\}/a_o]^{-1}$ (1). This potential is defined by three parameters, V, r_o and a_o. By optimizing the calculations to experimentally measured elastic scattering data, nuclear physicists obtained the potential parameters for proton scattering from many nuclei at various energies.

The unambiguous quantity for each potential is the volume integral per target nucleon, J_R/A, which is the integral of the Woods-Saxon potential function divided by the mass number of the target nucleus. We calculated J_R/A for all published potentials. This was done by numerical integration. These values were ordered as a function of energy. The values of J_R/A had a large spread at low energies, ranging from ~200 to ~1000 MeV fm^3. This is due to the Coulomb repulsion, which prevents the proton from getting into the nuclear interior. Thus the proton samples only the surface region of the nucleus. Therefore the derived potentials have large uncertainties and hence lead to this large spread. As the energy increases the proton penetrates deeper into the nucleus and the spread decreases. Thus a plot of J_R/A versus E forms a cone shape, leading to single values at the higher energies.

Since it is improper to choose any value over another, we decided to obtain averages of the volume integrals. These averages were carried out in 1 MeV bins. The averaged values considerably reduced the spread. A least squares fit to the data showed a logarithmic dependence of the volume integrals on the incident proton energy of the form:

$$J_R(E) = J_R(0) - \beta \ln E$$

with $J_R(0) = 846$ MeV fm^3 and $\beta = 132$ MeV fm^3. This shows that the volume integrals decrease as the energy increases. This is due to the variation of the two components of the potential. The attractive mean field decreases with energy because the proton traverses the nucleus more quickly as the energy increases. This is important at low energies. The repulsive nucleon-nucleon potential increases as the proton gets closer to the nucleons in the nucleus. Thus this component increases with energy. Therefore the total attractive potential decreases with energy as shown by the energy dependence equation.

The net attractive potential keeps decreasing until it goes to zero at about 600 MeV. At this energy the two components of the potential cancel each other. Beyond 600 MeV, the repulsive component dominates, and the total potential is repulsive.

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